

STANDARD SPECIFICATION**SECTION 03300****CAST-IN-PLACE CONCRETE**

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STANDARD SPECIFICATION

SECTION 03300

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

- A. Section Includes: Cast-in-place concrete, including formwork, reinforcing, mix design, placement procedures, and finishes.
- B. Related Sections: Refer to the following sections for related work:
 - 1. Division 2, Section “Earthwork.”
 - 2. Division 5, Section “Structural Steel.”
 - 3. Division 7, Section “Joint Sealants.”

1.02 REFERENCES

- A. American Concrete Institute (ACI)
- B. American Society for Testing and Materials (ASTM)
 - A82 Specification for Cold-Drawn Steel Wire for Concrete Reinforcement
 - A185 Specification for Steel Welded Wire Fabric, Plain for Concrete Reinforcement
 - A615 Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
 - C31 Practice for Making and Curing Concrete Test Specimens in the Field
 - C33 Specification for Concrete Aggregates
 - C39 Test Method for Compressive Strength of Cylindrical Concrete Specimens
 - C42 Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
 - C94 Specification for Ready-Mixed Concrete
 - C143 Test Method for Slump of Hydraulic Cement Concrete

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- C150 Specification for Portland Cement
- C172 Practice for Sampling Freshly Mixed Concrete
- C231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- C260 Specification for Air-Entraining Admixtures for Concrete
- C309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete
- C494 Specification for Chemical Admixtures for Concrete
- C618 Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
- C1107 Specification for Packaged Dry, Hydraulic-Cement Grout (non-shrink)
- C1116 Specification for Fiber-Reinforced Concrete and Shotcrete
- D994 Specification for Preformed Expansion Joint Filler for Concrete
- D1751 Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction
- D1752 Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
- C. Concrete Reinforcing Steel Institute (CRSI)
- D. PS 1 US Product Standard for Construction and Industrial Plywood

1.03 SUBMITTALS

- A. General: Submit the following items in accordance with the Conditions of Contract and Division 1, Section “Descriptive Submittals.”
- B. Product Data: Submit product data for the following materials and items.
 - 1. Reinforcement
 - 2. Forming Accessories
 - 3. Admixtures
 - 4. Patching Compounds
 - 5. Hardener
 - 6. Joint Systems
 - 7. Curing Compounds
 - 8. Sealants
- C. Shop Drawings: Submit detailed shop drawings for fabrication, bending and placement of concrete reinforcement.
 - 1. Show bar schedules, stirrup spacing, diagrams of bent bars and arrangement of reinforcement including bar overlap.

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2. Include special reinforcement required for openings through concrete structures.
- D. Laboratory Test Reports: Submit concrete materials test reports and mix design reports certifying that each material or item complies with or exceeds the specified requirements.

1.04 QUALITY ASSURANCE

- A. Codes and Standards: Comply with provisions of the following, except as otherwise indicated:
1. ACI 301 “Specifications for Structural Concrete for Buildings”
 2. ACI 302 “Guide for Concrete Floor and Slab Construction”
 3. ACI 304 “Guide for Measuring, Mixing, Transporting and Placing Concrete”
 4. ACI 305 “Hot Weather Concreting”
 5. ACI 306 “Cold Weather Concreting”
 6. ACI 308 “Standard Practice for Curing Concrete”
 7. ACI 309 “Standard Practice for Consolidation of Concrete”
 8. ACI 315 “Details and Detailing of Concrete Reinforcement”
 9. ACI 318 “Building Code Requirements for Reinforced Concrete”
 10. ACI 347 “Recommended Practice for Concrete Formwork”
 11. CRSI “Manual of Standard Practice”
 12. SP-66 “ACI Detailing Manual”
- B. Quality Control Testing During Construction: Sandia National Laboratories (SNL) will engage concrete testing service for quality control testing during concrete operations.
1. Notify Sandia Delegated Representative (SDR) at least two (2) working days in advance of field operations requiring concrete testing, or of resumption of operations after stoppages.
 2. Coordinate concrete operations with testing service to facilitate quality control testings.
 3. Sample and test concrete during placement of concrete as follows:
 - a. Sampling Fresh Concrete: ASTM C172, except modified for slump to comply with ASTM C94.
 - b. Slump: ASTM C143; one test for each concrete load at point of discharge and one for each set of compressive strength test specimens.

- c. Air Content: ASTM C231, pressure method; one for each set of compressive strength specimens.
 - d. Compression Test Specimens: ASTM C31; one (1) set of six (6) standard cylinders for each compressive strength test, unless otherwise directed. Accommodate testing service to store cylinders on site for the first twenty-four hours after molding.
 - e. Concrete Temperature: Test hourly when air temperature is 40 degrees F (4 degrees C) and below, and when 80 degrees F (27 degrees C) and above; and each time that a set of compression test specimens is made.
 - f. Compressive Strength Tests: ASTM C39; one (1) set for each 150 cubic yards (115 cubic meters) or fractions thereof, of each concrete class placed in any one day or for each 5000 sq. ft. (465 square meters) of surface area placed; two (2) specimens tested seven (7) days, three (3) specimens tested 28 days and one (1) specimen retained in reserve for later testing if required.
3. If the average strength of six (6) consecutive cylinders tested at 28 days falls below the required compressive strength or if any individual strength test (average of two test cylinders) falls more than 500 psi (3.5 MPa) below the specified strength, the in-place concrete represented by the low-strength cylinders shall be tested at the Contractor's expense by one of the following methods as directed by the SDR by a laboratory acceptable by the SDR.
- a. Core Drilling: ASTM C42, "Standard Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete," and ACI 318, Section 5.6.4.
 - b. Load Testing: Load tests shall be performed in accordance with Chapter 20, "Strength Evaluation of Existing Structures," of ACI 318.

PART 2 - PRODUCTS

2.01 FORM MATERIALS FOR STRUCTURAL COMPONENTS

- A. Forms for Exposed Finish Concrete: Unless otherwise indicated, construct formwork with plywood, metal, metal framed plywood faced or other acceptable panel type materials to provide continuous, straight, smooth, exposed surfaces.
 - 1. Furnish in largest practicable sizes to minimize number of joints and to conform to joint system shown on Contract Drawings.
 - 2. Provide form material with sufficient thickness to withstand pressure of newly placed concrete without bow or deflection.
 - 3. Provide forms that comply with US Product Standard PS 1 and the following:
 - a. B-B High Density Overlaid Concrete Form, Class I.
 - b. B-B (Concrete Form) Plywood, Class I, exterior grade or better, mill oiled and edge sealed, with each piece bearing legible inspection trademark.

- B. Forms for Unexposed Finish Concrete: Provide forms of plywood, lumber, metal or other acceptable material. Provide lumber dressed on at least two (2) edges and one (1) side for tight fit.
- C. Forms for Textured Finish Concrete: Provide forms with units of face design, size, arrangement and configuration as shown on Contract Drawings, or as required to match control sample.
- Provide solid backing and form supports to ensure stability of textured form liners.
- D. Cylindrical Columns and Supports: Form round-section members with paper or fiber tubes, constructed of laminated plies using water-resistant adhesive with wax-impregnated exterior for weather and moisture protection.
- Provide units with sufficient wall thickness to resist loads imposed by wet concrete without deformation.
- E. Form Coatings: Provide commercial formulation form-coating compounds that will not bond with, stain, nor adversely affect concrete surfaces, and will not impair subsequent treatments of concrete surfaces.
- F. Form Ties: Provide factory-fabricated, adjustable-length, removable or snapoff metal form ties, designed to prevent form deflection, and to prevent spalling concrete surfaces upon removal.
1. Unless otherwise indicated, provide ties so portion remaining within concrete after removal is at least 1/2 inch (12.7 mm) inside concrete for steel ties and 1/4 inch (6.35 mm) for wire ties.
 2. Unless otherwise shown, provide form ties which will not leave holes larger than 1 inch (25 mm) diameter in concrete surface.

2.02 FORM MATERIALS FOR SIDEWALKS, CURBS AND GUTTERS

- A. General: Design and construct form work to insure that finished concrete will conform accurately to indicated dimensions, lines, and elevations, and within the tolerances specified.
1. Provide forms of wood or steel, straight, and of sufficient strength to resist springing during depositing and consolidating concrete.
 2. Wood Forms: Surfaced plank, 2 inch (51 mm) nominal thickness, straight and free from warp, twist, loose knots, splits or other defects.
 - a. Nominal Length: 10 feet (3 m).
 - b. Radius bends may be formed with 3/4 inch (19.1 mm) boards, laminated to the required thickness.
 3. Steel Forms: Channel-formed sections with flat top surface, welded braces at each end and at not less than two (2) intermediate points.
 - a. Ends of steel forms shall be interlocking and self-aligning.

- b. Provide flexible forms for radius forming, corner forms, form spreaders, and fillers.
 - c. Nominal Length: 10 feet (3 m) with a minimum of three (3) welded stake pockets per form for straight forms and a minimum of seven (7) welded stake pockets per form for radius forms.
 - d. Stake Pins: Solid steel rods with chamfered heads and pointed tips designed for use with steel forms.
- B. Sidewalk Forms: Provide forms of height equal to full depth of finished sidewalk.
- C. Curb and Gutter Forms: Provide forms of height equal to full depth of curb or gutter.
- 1. Provide batter as indicated for inside form of curb, securely fastened to and supported by the outside form.
 - 2. Provide rigid forms for curb returns, except that benders or thin plank forms may be used for curb or curb returns with a radius of 10 feet (3 m) or more, where grade changes occur in the return, or where the central angle is such that a rigid form with a central angle of 90 degrees cannot be used.
 - 3. Back forms for curb returns may be made of 1-1/2 inch (38.1 mm) benders, for full height of the curb, cleated together.

2.03 REINFORCING MATERIALS

- A. Cold-drawn steel wire: ASTM A82.
- B. Welded wire fabric: ASTM A185, welded steel wire fabric.
- Furnish in flat sheets, not rolls, unless rolls are acceptable to the SDR.
- C. Reinforcing Bars: ASTM A615, deformed.
- 1. Provide Grade 40 bars No. 3 and 4 for stirrups and ties.
 - 2. Provide Grade 60 bars No. 3 to 18, except as otherwise noted.
- D. Supports for Reinforcement: Provide supports for reinforcement including bolsters, chairs, spacers and other devices for spacing, supporting and fastening reinforcing bars and welded wire fabric in place.
- 1. Use wire bar type supports complying with CRSI recommendations, unless otherwise indicated. Do not use wood, brick, stone, broken block or pieces of concrete.
 - 2. For concrete-on-grade, use supports with sand plates or horizontal runners if base material will not adequately support chair legs.

3. For exposed-to-view concrete surfaces, where legs of supports are in contact with forms, provide supports with legs which are plastic protected, stainless steel protected, or special stainless complying with CRSI Classes, C, D, or E respectively.
- E. Fibrous Reinforcement: ASTM C1116.
- F. Shop fabricate reinforcing bars to conform to required shapes and dimensions, with fabrication tolerances complying with ACI 315. In case of fabricating errors, do not rebend or straighten reinforcement in manner that will injure or weaken material.
- G. Unacceptable Materials: Defective reinforcement shall not be permitted in work:
1. Bar lengths, depths and bends exceeding specified fabrication tolerances.
 2. Bends or kinks not indicated on Contract Drawings or final shop drawings.
 3. Bars with reduced cross section due to excessive rusting or other cause.
 4. Bars bent in the field and bars bent by heating.

2.04 CONCRETE MATERIALS

- A. Portland Cement: ASTM C150 Types I-II and III, “Low-Alkali” cement, unless otherwise specified. Use one brand of cement throughout project unless otherwise acceptable to the SDR
- B. Aggregates: ASTM C33; provide aggregates from single source for exposed concrete. Do not use sandstone aggregates.
1. Fine Aggregate: Clean, sharp, natural sand free from loam, clay lumps or other deleterious substances. Do not use dune, bank run, or manufactured sand.
 2. Coarse Aggregate: Clean, uncoated, processed aggregate containing no clay, mud, loam or foreign matter, as follows:
 - a. Crushed stone, processed from natural rock or stone.
 - b. Natural or crushed gravel. Do not use pit or bank run gravel.
 3. Maximum Aggregate Size: Not larger than one-fifth (1/5) of the most narrow dimension between side or forms, one-third (1/3) of the depth of slabs, or three-fourths (3/4) of the minimum clear spacing between individual reinforcing bars or bundles of bars.

If workability and consolidation methods indicate concrete can be placed without honeycomb or voids, limitations may be waived if approved by SDR.
- C. Water: Potable, clean, fresh, free from oil, acid, organic matter or other deleterious substances.
- D. Fly Ash: ASTM C618, Class F; use one brand of fly ash throughout project unless otherwise acceptable to the SDR.

- E. Admixtures: All admixtures shall be specified in the mix design.
1. Air-Entraining Admixture: ASTM C260
 2. Water-Reducing Admixture: ASTM C494, Type A.
 3. High Range Water-Reducing Admixture (Super Plasticizer): ASTM C494, Type F or Type G.
 4. Water-Reducing, Retarding Admixture: ASTM C494, Type D.
 5. Chloride-containing admixtures are not permitted.

2.05 RELATED MATERIALS

A. Expansion Joint Materials

1. Typical Building and Concrete Paved Roadway Joints: ASTM D994, preformed strips of a bituminous mastic composition.
2. Slabs-in-Ground, Sidewalks, and Curb and Gutter Joints: ASTM D1751, preformed expansion joint filler having relatively little extrusion and substantial recovery after release from compression.
3. Hydraulic Structure Joints: ASTM D1752, preformed expansion joint fillers as specified on the Contract Documents.

B. Non-Shrink Grout: ASTM C1107, factory pre-mixed, non-metallic grout.

C. Liquid Membrane-Forming Curing Compound: ASTM C309, Type I or I-D, Class A.

D. Chemical Hardener: Hardener shall be a colorless, aqueous solution of zinc or magnesium fluosilicate. Approved proprietary hardeners shall be delivered ready for use in the manufacturer's original containers.

E. Bonding Compound: Polyvinyl acetate, rewettable type.

F. Nonslip Aggregate Finish: Where indicated in the Contract Drawings, provide fused aluminum oxide grits, or crushed emery, as abrasive aggregate for nonslip finish with emery aggregate containing not less than 40% aluminum oxide and not less than 25% ferric oxide.

Use material that is factory graded, packaged, rust-proof and nonglazing, and is unaffected by freezing, moisture and cleaning materials.

2.06 CONCRETE MIX DESIGN

A. General: Minimum 3000 psi (20.7 MPa) compressive strength at 28 days, unless otherwise indicated.

1. Pavements, Sidewalks, Curbs and Gutters: 4000 psi (27.6 MPa) compressive strength at 28 days.

2. Provide concrete mixtures with desired strength and necessary workability in fresh concrete.
3. Provide “Ready-Mixed” concrete, unless otherwise approved or specified; in accordance with ASTM C94.
4. Select water-to-cementitious materials ratio required to produce 28-day strength corresponding to over designed mix which is supported by sufficient experience data to assure that test results will fall within limits established in specification. Unless otherwise specified, the following proportions apply:

Strength psi	Min. Cement Bag/CY	Max. W/(C+FA)* Ratio Non-Air-Entrained	Max. W/(C+FA)* Ratio Air-Entrained
3000 (20.7 MPa)	5.0	0.60	0.58
4000 (27.6 MPa)	6.0	0.52	0.47

* W/(C+FA) = Water to cementitious material, cement plus fly ash by weight.

5. Slump due to water content alone (without the addition of super plasticizer) shall be as follows:

<u>Allowable Slump</u>	<u>Min-Max (inch)</u>
Reinforced foundation walls and footings	1-3 (25-76 mm)
Unreinforced footings, caissons and substructure walls	1-3 (25-76 mm)
Reinforced slabs, beams and walls	1-4 (25-102 mm)
Building columns	2-3 (51-76 mm)
Pavements	1-2 (25-51 mm)
Sidewalls, driveways and slabs-on-ground	2-4 (51-102 mm)
Heavy mass construction	1-2 (25-51 mm)
Sidewalks, curbs and gutters	2-4 (51-102 mm)

After the addition of super plasticizers, slumps may range from 3 to 11 inches (76 mm to 279 mm) provided that the concrete mix is cohesive and non-segregating, has controlled time of set and minimal bleed water.

B. Aggregate: ASTM C33, and as follows:

1. Coarse Aggregate: Table 2, Grading Requirements for Coarse Aggregates.
2. Fine Aggregate: Sieve Analysis, Fine Aggregate.

C. Admixtures

1. Use water-reducing admixture or high range water-reducing admixture (super plasticizer) in all concrete.
2. Use air-entraining admixture in exterior exposed concrete, unless otherwise indicated. Use air content of 3.5 to 6.5%.
3. When air-entraining admixture is used solely for increasing workability of mix, use air content of 3 to 5%.
4. Fly Ash: Fly ash shall be used in all concrete mixes. Class F fly ash shall be proportioned by weight of cement to provide fly ash to Portland cement ratio not

less than 20%, or greater than 25% of the sum of total weight of fly ash and cement.

- D. High early strength concrete shall have compressive strength at 7 days equal to that specified for ordinary concrete at 28 days.

2.07 PLANT, EQUIPMENT, MACHINES, AND TOOLS

- A. General: Plant, equipment, machines, and tools used in the work shall be subject to approval and shall be maintained in a satisfactory working condition at all times.
1. Provide equipment with capability of producing the required product, meeting grade controls, thickness control and smoothness requirements as specified.
 2. Use of equipment shall be discontinued if it produces unsatisfactory results.
 3. SDR shall have access at all times to the plant and equipment to ensure proper operation and compliance with specifications.
- B. Slip Form Equipment: Self-propelled, automatically controlled, crawler mounted, and capable of spreading, consolidating, and shaping the plastic concrete to desired cross section in one pass.

Slip form paver or curb-forming machine, will be approved based on trial use on the job.

- C. Soft-Cut Saw: Designed and shown to be able to cut concrete shortly after final set without causing raveling or other untoward effect upon the concrete finish.

Provide diamond blade with thickness no greater than 1/8 inch (3.18 mm) to soft-cut joint of size indicated.

PART 3 - EXECUTION

3.01 FORM SETTING FOR STRUCTURAL COMPONENTS

- A. Design, erect, support, brace and maintain formwork to support vertical and lateral loads that might be applied until such loads can be supported by concrete structure.
- B. Construct formwork so concrete members and structures are of correct size, shape, alignment, elevation and position.
- C. Provide for openings, keyways, chamfers, inserts and other features required in work.
- D. Maintain formwork construction tolerances, unless otherwise indicated:
1. Variation from Plumb:

- a. In the lines and surfaces of columns, piers, walls, and in arrises:

In any 10 feet (3 m) of length 1/4 inch (6.35 mm)

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- Maximum for the entire length..... 1 inch (25 mm)
- b. For exposed corner columns, control-joint grooves, and other conspicuous lines:
- In any 20 foot (6 m) length 1/4 inch (6.35 mm)
- Maximum for the entire length..... 1/2 inch (12.7 mm)
2. Variation from level or from grades specified in Contract Drawings:
- a. In slab soffits, ceilings, beam soffits and in arrises, measured before removal of supporting shores:
- In any 10 feet (3 m) of length 1/4 inch (6.35 mm)
- In any bay or in any 20 foot (6 m) length 3/8 inch (9.53 mm)
- Maximum for the entire length..... 3/4 inch (19.1 mm)
- b. In exposed lintels, sills, parapets, horizontal grooves, and other conspicuous lines:
- In any bay or in 20 foot (6 m) length..... 1/4 inch (6.35 mm)
- Maximum for the entire length..... 1/2 inch (12.7 mm)
3. Variation of the linear building lines from established position in plan and related position of columns, walls, and partitions:
- In any bay 1/2 inch (12.7 mm)
- In any 20 foot (6 m) of length..... 1/2 inch (12.7 mm)
- Maximum for the entire length..... 1 inch (25 mm)
4. Variation in the sizes and location of sleeves, floor openings, and wall openings 1/4 inch (6.35 mm)
5. Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls:
- Minus..... 1/4 inch (6.35 mm)
- Plus 1/2 inch (12.7 mm)
6. Footings*:
- a. Variations in dimensions in plan:
- Minus..... 1/2 inch (12.7 mm)
- Plus 2 inches (51 mm)
- b. Misplacement or eccentricity:
- 2% of the footing width in direction of misplacement but not more than..... 2 inches (51 mm)
- c. Thickness:
- Decrease in specified thickness.....5%
- Increase in specified thickness.....No limit

7. Variation in Steps:

a. In a flight of stairs:

Rise+1/8 inch (+3.18 mm)
Tread.....+1/4 inch (+6.35 mm)

b. In consecutive steps:

Rise+1/16 inch (+1.588 mm)
Tread.....+1/8 inch (+3.18 mm)

* Tolerances apply to concrete dimensions only.

- E. Design and fabricate formwork to be readily removable without impact, shock or damage to cast-in-place concrete surfaces and adjacent materials.
- F. Chamfer all exposed corners and edges to produce uniform smooth lines and tight edge joints, unless otherwise indicated in the Contract Drawings.
- G. Provisions for Other Trades: Provide openings in concrete formwork to accommodate work of other trades.
1. Determine size and location of openings, recesses and chases from trades providing such items.
 2. Accurately place and securely support items built into forms.

3.02 FORM SETTING FOR SIDEWALKS, CURBS AND GUTTERS

A. General: Set forms to the indicated alignment, grade and dimensions.

1. Provide minimum of three (3) stakes per form placed at intervals not to exceed 4 feet (1.2 m) to hold forms rigidly in place.
2. Provide additional stakes and braces for corners, deep sections, and radius bends, as required.
3. Provide clamps, spreaders, and braces where required to insure rigidity in forms.
4. Clean and coat forms with form oil each time before concrete is placed.
5. Wood forms may be thoroughly wetted with water before concrete is placed, except when probable freezing temperatures may occur, oiling is mandatory.

B. Divide curb, and combined curb and gutter into blocks or stones in lengths not to exceed 6 feet (2 m) long.

1. Use metal templates not less than 1/16 inch (1.588 mm) thick cut to the same cross section as the curb or curb and gutter being constructed.
2. Securely attach templates to forms to prevent movement during concrete placement.

- C. Sidewalks, Curbs and Gutters: Set forms for sidewalks, curbs and gutters with the upper edge true to line and grade with an allowable tolerance of 1/8 inch (3 mm) in any 10 foot (3 m) long section.
1. After forms are set, check grade and alignment with 10-foot (3 m) straightedge.
 2. Provide transverse slope of 1/4 inch per foot (6.35 mm per meter) with low side adjacent to the roadway.

3.03 PLACING REINFORCEMENT

- A. Comply with CRSI's recommended practice for "Placing Reinforcing Bars," for details and methods of reinforcement placement and supports, and as herein specified. Field bending of grade 60 bars is not permitted.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, oil, concrete splatter from previous pours, and other materials which reduce or destroy bond with concrete.
- C. Accurately position, support and secure reinforcement against displacement by formwork, construction, or concrete placement operations. Locate and support reinforcing by metal chairs, runners, bolsters, spacers, and hangers, as required.
- D. Install welded wire fabric of same gage in as long of lengths as practicable. Lap adjoining pieces at least one full mesh and lace splices with wire. Offset end laps of adjacent widths to prevent continuous laps in either direction.
- E. Provide minimum cover for reinforcement of cast-in-place concrete, unless otherwise indicated.

Concrete cast against and permanently exposed to earth	3 inches (76 mm)
Concrete exposed to earth or weather	
#6 and larger	2 inches (51 mm)
#5 and smaller	1-1/2 inches (38 mm)
Concrete not exposed to weather or in contact with earth	
Slabs, walls, joists	3/4 inch (19 mm)
Beams, columns.....	1-1/2 inches (38 mm)

3.04 JOINTS

- A. Construction Joints: Locate construction joints on slab floor, which are not shown on Contract Drawings, and notify SDR for approval.
1. Provide keyways at least 1-1/2 inches (38.1 mm) deep in construction joints in walls and between walls and footings; accepted preformed keyways designed for this purpose may be used for slabs.
 2. Place construction joints perpendicular to main reinforcement. Continue reinforcement across construction joints.

B. Isolation Joints: Construct isolation joints in slabs-on-ground at points of contact between slabs on ground and foundations as shown on Contract Drawings. Unless otherwise indicated, install 90# felt paper between slab and vertical surface.

C. Contraction (Control) Joints

1. Contraction Joints in Slabs-on-Grade: Construct contraction joints in slabs-on-grade to form panels of patterns as shown. Use saw cuts 1/8 inch (3.18 mm) wide by one-fourth of slab depth, or inserts 1/4 inch (6.32 mm) wide by one-fourth of slab depth, unless otherwise indicated.

a. Form contraction joints by inserting premolded plastic, hardboard, or fiberboard strip into fresh concrete until top surface of strip is flush with slab surface.

Tool slab edges round on each side of insert. Remove inserts and clean groove of loose debris after concrete has cured.

b. Form contraction joints in unexposed floor slabs by saw cuts as soon as possible after slab finishing as may be safely done without dislodging aggregate.

Contraction joints formed by soft-cut saw shall be made no greater than eight hours after placement of concrete.

c. If joint pattern is not indicated in Contract Drawings, provide joints at intervals not exceeding 30 times the slab thickness in either direction, and located to conform to bay spacing wherever possible (at column centerlines, half bays, third bays).

2. Sidewalks: Construct joints to divide surface into rectangular areas.

a. Space transverse contraction joints at distance equal to sidewalk width or 5 feet (1.5 m) on center, whichever is less, and continuous across slab.

b. Construct longitudinal contraction joints along centerline of sidewalks 10 feet (3 m) or more in width.

c. Form contraction joints in fresh concrete by cutting groove in top portion of slab to depth of at least one-fourth of sidewalk slab thickness.

(1) Use jointer to cut groove, or saw groove in hardened concrete with power-driven saw, unless otherwise approved.

(2) Construct sawed joints by sawing groove in concrete with 1/8 inch (3.18 mm) blade to the depth indicated on Contract Documents.

3. Curb and Gutter: Construct joints at right angles to line of curb and gutter.

a. Construct contraction joints directly opposite contraction joints in abutting Portland cement concrete pavements.

b. Space joints so that monolithic sections between curb returns will not be less than 5 feet (1.5 m) nor greater than 15 feet (4.5 m) in length.

- c. Form contraction joints with 1/8 inch (3.18 mm) thick separators, with section conforming to curb and gutter cross section .
- d. Remove separators as soon as practicable after concrete has set sufficiently to preserve width and shape of joint and prior to finishing.

D. Expansion Joints

1. Slabs-on-Ground: Expansion joint material shall be placed around utility access openings within the slab, including clean outs and utility valves, and between new concrete slab and adjacent masonry.
 - a. Provide premolded, asphalt impregnated joint material 1/2 inch (12.7 mm) thick .
 - b. Extend joint material to full depth of concrete.
2. Sidewalks: Place joints in sidewalks at point of tangency (PT) and point of curvature (PC) of sidewalk returns, between sidewalk and building or structure, in sidewalk returns, between sidewalk and back of curb returns and around utility poles.
 - a. Provide joint material 1/2 inch (12.7 mm) thick.
 - b. Extend joint filler strips to full depth of concrete being placed at PT, PC, and around utility poles,
 - c. Provide joint filler strips between sidewalk and curb to full depth of sidewalk with top of filler strip set flush with top of curb.
 - d. Provide transverse sidewalk joints at spacing not to exceed 30 feet (9 m).
3. Curbs and Gutters: Form expansion joints with preformed expansion joint filler material 1/2 inch (12.7 mm) wide. Cut and shape to curb and gutter cross section.
 - a. Provide expansion joints in curb and gutter at end of returns except where cross gutters are being constructed.
 - b. Provide expansion joints at ends of cross gutter transitions and along line of work at regular intervals, not to exceed 36 feet (11 m).
 - c. Provide joints in gutter continuous with those in adjacent curb.

3.05 PREPARATIONS FOR PLACING CONCRETE

- A. Remove water from excavations. Before placement of concrete, remove wood chips, shavings, and hardened concrete from forms.
1. Clean all equipment.
 2. Wet forms, except in freezing weather, or oil forms.

- B. Earth shall be uniformly moist when concrete is placed. Sprinkling method shall not be such as to form mud or pools of water.

Watering subgrade immediately prior to placing concrete is not sufficient to make the soil uniformly moist.

- C. Notify other crafts to permit installation of their work. Coordinate installation of joint materials and moisture barriers with placement of forms and reinforcing steel.

3.06 PLACING CONCRETE

- A. Notify SDR 24 hours in advance prior to concrete placement.
- B. Field Inspection: Do not place concrete until forms and reinforcing steel have been inspected and approved.

1. Place Ready-Mix concrete within specified time after batching.

Below 40 degrees F (4 degrees C)	See Cold Weather Placing
40 - 85 degrees F (4 - 29 degrees C)	90 minutes
86 - 90 degrees F (30 - 32 degrees C)	75 minutes
Above 90 degrees F (32 degrees C)	60 minutes

Concrete exceeding delivery time may be rejected by the SDR.

2. Adding Water: Do not add water after initial introduction of mixing water for batch except when slump of concrete is less than that specified upon arrival at job site, and maximum water/cement ratio for mix has not been exceeded.
- a. Notify SDR before adding any water.
- b. Add water to bring slump within specified limits. Turn drum at least 30 additional revolutions at mixing speed. Do not add water to batch at any later time.
- c. Insure that concrete strength meets specified requirements, and water does not exceed maximum amount specified in CONCRETE MIX DESIGN.

- C. General: Comply with ACI 304, and as specified herein.

1. Deposit concrete continuously or in layers of such thickness that concrete will not be placed on concrete which has hardened sufficiently to cause formation of seams or planes of weakness.
2. If section cannot be placed continuously, provide construction joints as specified herein. Deposit concrete as nearly as practicable to its final location to avoid segregation.

- D. Placing Concrete in Forms: Deposit concrete in forms in horizontal layers not deeper than 24 inches (610 mm) and in a manner to avoid inclined construction joints.

1. Where placement consists of several layers, place each layer while preceding layer is still plastic to avoid cold joints.

2. Consolidate placed concrete by high frequency mechanical vibrating equipment, supplemented as necessary by hand-spading, rodding or tamping. Use equipment and procedures for consolidation of concrete in accordance with ACI 309.
 - a. Do not use vibrators to transport concrete inside forms.
 - b. Insert and withdraw vibrators vertically at uniformly spaced locations not farther than visible effectiveness of machine.
 - c. Place vibrators to rapidly penetrate placed layer and at least 6 inches (152 mm) into preceding layer.
 - d. Do not insert vibrators into lower layers of concrete that have begun to set.
 - e. At each insertion, limit duration of vibration to time necessary to consolidate concrete, and complete embedment of reinforcement and other embedded items without causing segregation of mix.
 3. Concrete shall not be allowed to free fall more than 5 feet (1.5 m) unless confined by a closed chute. Concrete placed in walls 10 inches (254 mm) or less in thickness may free fall maximum of 8 feet (2.4 m).
- E. Placing Concrete Slabs: Deposit and consolidate concrete slabs in continuous operation, within limits of construction joints, until placement of panel or section is completed.
1. Bring slab surfaces to correct level as above, and use bull floats or darbies to smooth surface, free of humps or hollows. Do not use tools such as jitterbugs that force the aggregate away from surface.
 2. Maintain reinforcing in proper position during concrete placement operations.
- F. Placing Concrete Sidewalks: Place concrete in forms in one (1) layer of such thickness that when consolidated and finished, sidewalks will be of thickness indicated.
1. Use strike-off guided by side forms to bring surface to proper section to be compacted.
 2. Consolidate concrete with approved vibrator, and finish surface to grade with wood float, bull float, or darby, edged and broom finished.
 3. Surface Tolerance: Maximum 5/16 inch (7.9 mm) from the testing edge of 10 foot (3 m) straightedge.
 4. Section Thickness Tolerance: Maximum 1/4 inch (6.35 mm).
- G. Placing Concrete Curb and Gutter: Place concrete to section required in single lift. Consolidate by using approved mechanical vibrators.
1. Surface Tolerance: Maximum 1/4 inch (6.35 mm) from the testing edge of 10 foot (3 m) straightedge.
 2. Section Thickness Tolerance: Maximum 1/4 inch (6.35 mm).

- H. Cold Weather Placing: Protect concrete work from physical damage or reduced strength which could be caused by frost, freezing actions, or low temperatures; comply with ACI 306 and these specifications.
1. Mix and place concrete only when temperature is at least 40 degrees F (4 degrees C) and rising, unless permission to pour is obtained from SDR.
 2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
 3. Do not use calcium chloride, salt and other materials containing antifreeze agents or chemical accelerators.
 4. When approval is obtained to place concrete at or below an atmospheric temperature of 40 degrees F (4 degrees C), heat water or aggregates, or both. Provide suitable enclosures and heating devices.
 - a. Temperature of mixed concrete shall be not less than 50 degrees F (10 degrees C) and not more than 90 degrees F (32 degrees C) at time of placement.
 - b. Record temperature of concrete for each truck as delivered and after placement in forms.
 - c. Provide heating equipment or methods capable of heating water and aggregates uniformly. Heat materials to temperature not greater than 150 degrees F (66 degrees C).
 5. After concrete placement, provide suitable measures to maintain concrete surface temperature at 40 degrees F (4 degrees C) or above for period not less than seven (7) days.
- I. Hot Weather Placing: When hot weather conditions exist that would seriously impair quality and strength of concrete, place concrete in compliance with ACI 305 and as herein specified.
1. Cool ingredients before mixing to maintain concrete temperature at time of placement below 90 degrees F (32 degrees C).
 2. Cover reinforcing steel with water-soaked burlap when required to ensure that steel temperature will not exceed the ambient air temperature immediately before embedment in concrete.
 3. Wet forms thoroughly before placing concrete.
 4. Use water-reducing retarding admixture (Type D) when required by high temperatures, low humidity, or other adverse placing conditions.
 5. Record temperature of concrete for each truck as delivered and after placing in forms. Record air content and slump for each truck.

3.07 CONCRETE FINISHING

- A. General: Do not use tools such as jitterbugs that force the aggregate away from surface.
1. Do not spray or sprinkle water onto concrete surface to aid in finishing.
 2. Avoid bringing more water than necessary to surface and avoid working surface any more than necessary to obtain required finish.
- B. Monolithic Slab Finishes
1. Float Finish: Apply float finish to slabs for driveways, exterior slabs, and interior floor slabs receiving additional coverings.
 - a. After screeding and consolidating concrete slabs, do not work surface until ready for floating.
 - b. Begin floating when surface water has disappeared or when concrete has stiffened sufficiently to permit operation of power-driven floats or by hand floating if area is small or inaccessible to power units.
 - c. Check and level surface plane to tolerance not exceeding 1/4 inch (6.35 mm) in 10 feet (3 m) when tested with 10 foot (3 m) straightedge. Cut down high spots and fill low spots. Uniformly slope surfaces to drains.
 - d. Immediately after leveling, refloat surface to a uniform, smooth, granular texture.
 2. Trowel Finish: Apply trowel finish to slab surfaces to be exposed-to-view, and slab surfaces to be covered with resilient flooring, paint or other thin film finish coating system.
 - a. After floating, begin first trowel finish operation. Begin final troweling when surface produces ringing sound as trowel is moved over surface.
 - b. Consolidate concrete surface by final hand-troweling operation, free of trowel marks, uniform in texture and appearance, and with surface plane tolerance not exceeding 1/8 inch (3.18 mm) in 10 feet (3 m) when tested with a 10 foot (3 m) straightedge.
 - c. Grind smooth surface defects which would telegraph through applied floor covering system.
 3. Nonslip Broom Finish: Apply nonslip boom finish to exterior concrete platforms, steps and ramps, and elsewhere as indicated.
 - a. Immediately after trowel finishing, slightly roughen concrete surface by brooming with fiber bristle broom perpendicular to main traffic route.
 - b. Coordinate required final finish with SDR before application.
 4. Liquid Chemical Hardener Finish: Apply chemical hardener finish to interior concrete floors where indicated after complete curing and drying of the concrete surface.

- a. Dilute liquid hardener with water, and apply in three (3) coats; first coat, 1/3 strength; second coat, 1/2 strength; third coat, 2/3 strength. Evenly apply each coat, and allow 24 hours for drying between coats.
 - b. Apply proprietary chemical hardeners, in accordance with manufacturer's printed instructions.
 - c. After final coat of chemical hardener solution is applied and dried, remove surplus hardener by scrubbing and mopping with water.
5. Nonslip Aggregate Finish: Apply nonslip aggregate finish to concrete stair treads, platforms, ramps, and elsewhere as indicated in Contract Drawings.
- a. After completion of float finishing, and before starting trowel finish, uniformly spread 25 lb (11 kg) of dampened nonslip aggregate per 100 square feet (9 sq m) of surface.
 - b. Tamp aggregate flush with surface using a steel trowel, but do not force below surface. After broadcasting and tamping, apply trowel finishing as herein specified.
 - c. After curing, lightly work surface with steel wire brush or abrasive stone, and water to expose nonslip aggregate.

C. Finish of Formed Surfaces

1. Rough Form Finish: For formed concrete surfaces not exposed-to-view in finish work or by other construction, unless otherwise indicated.
 - a. Texture for concrete surface is imparted by form facing material used.
 - b. Repair and patch tie holes and defective areas, with fins and other projections exceeding 1/4 inch (6.35 mm) in height rubbed down or chipped off.
2. Smooth Form Finish: For formed concrete surfaces exposed-to-view, or that are to be covered with coating material applied directly to concrete, or covering material applied directly to concrete, such as waterproofing, dampproofing, painting or other similar system.
 - a. As-cast concrete surface is obtained with selected form facing material, arranged orderly and symmetrically with minimum of seams.
 - b. Repair and patch defective areas with fins or other projections completely removed and smoothed.
 - c. Smooth Rubbed Finish: Provide smooth rubbed finish to scheduled concrete surfaces, which have received smooth form finish treatment, not later than 24 hours after form removal.
 - (1) Moisten concrete surfaces and rub with carborundum brick or other abrasive until uniform color and texture is produced.
 - (2) Do not apply cement grout other than that created by rubbing process.

d. Grout-Cleaned Finish: Provide grout cleaned finish, in color and texture, to scheduled concrete surfaces which have received smooth form finish treatment.

- (1) Combine one part gray Portland cement to 1-1/2 parts fine sand by volume, and mix with water to consistency of thick paint. Blend standard gray Portland cement and white Portland cement, amounts determined by trial patches, so that final color of dry grout will closely match adjacent surfaces.
- (2) Thoroughly wet concrete surfaces and apply grout to coat surfaces and fill small holes. Remove excess grout by scraping and rubbing with clean burlap. Keep damp by fog spray for at least 36 hours after rubbing.

3. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces occurring adjacent to formed surfaces, strike off smooth and finish with texture matching adjacent formed surfaces.

Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces, unless otherwise indicated.

D. Sidewalk Finishes: After straightedging, when most of water sheen has disappeared, and just before concrete hardens, finish surface to smooth and uniformly fine granular or sandy texture free of waves, irregularities, or tool marks.

1. Provide scored surface by brooming with fiber-bristle brush in direction transverse to that of traffic.
2. Finish slab edges carefully, including those at formed joints, with edger having radius of 1/8 inch (3.18 mm).
 - a. Edge transverse joint before brooming, and broom to eliminate flat surface left by surface face of edger.
 - b. Clean corners and edges which have crumbled and areas which lack sufficient mortar for proper finishing. Fill solidly with properly proportioned mortar mixture, and finish.

E. Curb and Gutter Finishes: Float and finish exposed with smooth wood float until true to grade and section, and uniform in texture.

1. Brush floated surfaces with fine-hair brush with longitudinal strokes. Round edges of gutter and top of curb to radius of 1/2 inch (127 mm) with edging tool.
2. Immediately after removal of front curb form, rub face of curb with wood or concrete rubbing block and water until blemishes, form marks, and tool marks have been removed.
3. While still wet, brush front curb surface in same manner as gutter and curb top.
4. Finish top surface of gutter and entrance to grade with wood float.
5. Finish curb edges at formed joints as indicated.

3.08 CONCRETE CURING

- A. General: Immediately after placing or finishing, and as soon as operation will not mar finish, concrete surfaces not covered by forms shall be protected against moisture loss.
1. Maintain protection for period of at least 7 days.
 2. Where formed surfaces are cured in forms, forms shall be kept continually wet.
 3. If forms are removed before end of curing period, continue curing as on unformed surfaces, using curing materials specified herein.
 4. Keep surfaces free of foot and vehicular traffic during curing period.
- B. Curing Methods: Provide curing of concrete by methods specified or by combinations thereof, as approved:
1. Polyethylene Coated Burlap Mats: Cover surfaces with specified mat lapped 12 inches (305 mm). Mat shall be weighted to prevent displacement. Immediately repair tears or holes by patching.
 2. Membrane Forming Curing Compound: Apply in two coat continuous operation, using not less than manufacturer's recommended rate of application. If unknown, apply at rate of 1 gallon (3.8 liters) per 200 square feet (18.6 square meters) for each coat.
 - a. Respray surfaces damaged by construction operations during curing.
 - b. Do not use membrane curing compounds on surfaces which are to be covered with coating material applied directly to concrete or with covering material bonded to concrete, such as other concrete, liquid floor hardener, waterproofing, dampproofing, membrane roofing, flooring, painting and other coatings and finish materials, unless otherwise acceptable to SDR.
 3. Water Curing: Water cure surfaces indicated to receive additional concrete or concrete fill, dustproofing and hardening treatments, stucco, plaster, or painting.

3.09 REMOVAL OF FORMS

- A. General: Do not remove forms for any portion of the structure until concrete is strong enough not to be damaged when forms are removed.
1. Remove forms without damage to concrete.
 2. Do not use bars or heavy tools against concrete in form removal.
 3. Promptly repair concrete found defective after form removal.
- B. If field operations are not controlled by cylinder tests, the following periods, exclusive of days when the temperature is below 40 degrees F (4 degrees C), may be used as a guide for removal of forms and supports:

Guide for Removal of Forms and Supports

Centering under beams	14 days
Elevated floor slabs	7-14 days*
Walls	12-24 hours*
Columns	1-7 days*
Sides of beams and all other parts	12-24 hours*

*Longer time dictates unless SDR approves lesser time.

- C. If field operations are controlled by beam or cylinder tests, forms may be removed from centering under beams and floor slabs when 2500 psi (17.2 MPa) compressive strength is attained, and approved by SDR.
- D. Do not place superimposed loads on or against load carrying members until 2500 psi (17.2 MPa) compressive strength has been attained, and approved by SDR.
- E. Sidewalk Forms: Do not remove side forms for twelve (12) hours after completion of finishing.
- F. Curb and Gutter Forms: Remove forms of curb front not less than two (2) hours nor more than six (6) hours after placement of concrete.
 - 1. Forms of curb back shall remain in place until face and top of curb have been finished as specified for concrete finishing.
 - 2. Do not remove gutter forms while concrete is sufficiently plastic to slump in any direction.

3.10 REUSE OF FORMS

- A. Clean and repair surfaces of forms to be reused in work.
- B. Maintain shape, strength, rigidity, water-tightness, and surface smoothness of reused forms at all times.
- C. Re-size warped or bulged lumber before use.
- D. Do not use unsatisfactory forms.

3.11 CONCRETE SURFACE REPAIRS

- A. Patching Defective Areas: Immediately after form removal, cut out honeycomb, rock pockets, voids over 1/4 inch (6.35 mm) in any dimension, and holes left by tie rods and bolts, down to solid concrete but, in no case to a depth of less than one (1) inch (25 mm).
 - 1. Cut edges perpendicular to concrete surface.
 - 2. Thoroughly clean, dampen with water, and brush coat area to be patched with neat cement grout or proprietary bonding agent before placing cement mortar or proprietary patching compound.

- B. Exposed-To-View Surfaces: Blend white Portland cement and standard Portland cement so that patching mortar will match surrounding color when dry.
1. Provide test areas at inconspicuous location to verify mixture and color match before proceeding with patching.
 2. Compact mortar in place and strikeoff slightly higher than surrounding surface.
- C. Repair of Formed Surfaces: Remove and replace concrete with defective surfaces if defects cannot be repaired to satisfaction of SDR.
1. Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycomb, rock pockets, fins and other projections on surface, and stains and other discolorations that cannot be removed by cleaning.
 2. Flush out form tie holes, fill with dry pack mortar, or precast cement cone plugs secured in place with bonding agent.
 3. Where possible, repair concealed formed surfaces that contain defects that affect concrete durability. If defects cannot be repaired, remove and replace concrete.
- E. Repair of Unformed Surfaces: Test unformed surfaces, such as monolithic slabs, for smoothness and verify surface plane to tolerances specified for each surface and finish. For unformed surfaces sloped to drain, use template having required slope to test for trueness.
1. Surface defects include crazing, cracks greater than 0.01 inch (0.25 mm) wide or which penetrate to reinforcement or completely through non-reinforced sections regardless of width, spalling, popouts, honeycomb, rock pockets, and other objectionable conditions.
 2. Repair finished unformed surfaces that contain defects which affect concrete durability.
 3. Correct high areas in unformed surfaces by grinding after concrete has cured at least 14 days.
 4. Correct low areas in unformed surfaces during, or immediately after completion of surface finishing operations by cutting out low areas and replacing with fresh concrete. Finish to blend into adjacent concrete. Use only approved proprietary patching compounds.
 5. Repair defective areas, except random cracks and single holes not exceeding 1 inch (25 mm) diameter, by cutting out and replacing with fresh concrete.
 - a. Remove defective areas to sound concrete with clean, square cuts and expose reinforcing steel with at least 3/4 inch (19.1 mm) clearance all around.
 - b. Dampen concrete surfaces in contact with patching concrete and brush with neat cement grout, or apply concrete bonding agent.
 - c. Mix patching concrete of same materials to provide concrete of same type of class as original concrete.

- d. Place, compact and finish to blend with adjacent finished concrete. Cure in the same manner as adjacent concrete.

3.12 CONCRETE TRUCK DISCHARGE

- A. Excess Concrete: Discharge excess concrete in mixer trucks that cannot be immediately used to area where it will not create an obstruction or hazard during construction.

Remove excess concrete from site in a timely manner to site approved by SDR.

- B. Wash Water Discharge: Discharge wash water from mixer trucks to ground surface in manner and at location where discharge cannot escape construction site, or be washed away to arroyos, storm sewers, or sanitary sewers by precipitation or other surface flows.
 - 1. Prior to project completion, remove wash water residue from site to location approved by SDR.
 - 2. Clean wash water discharge site to be free of debris.

END OF SECTION